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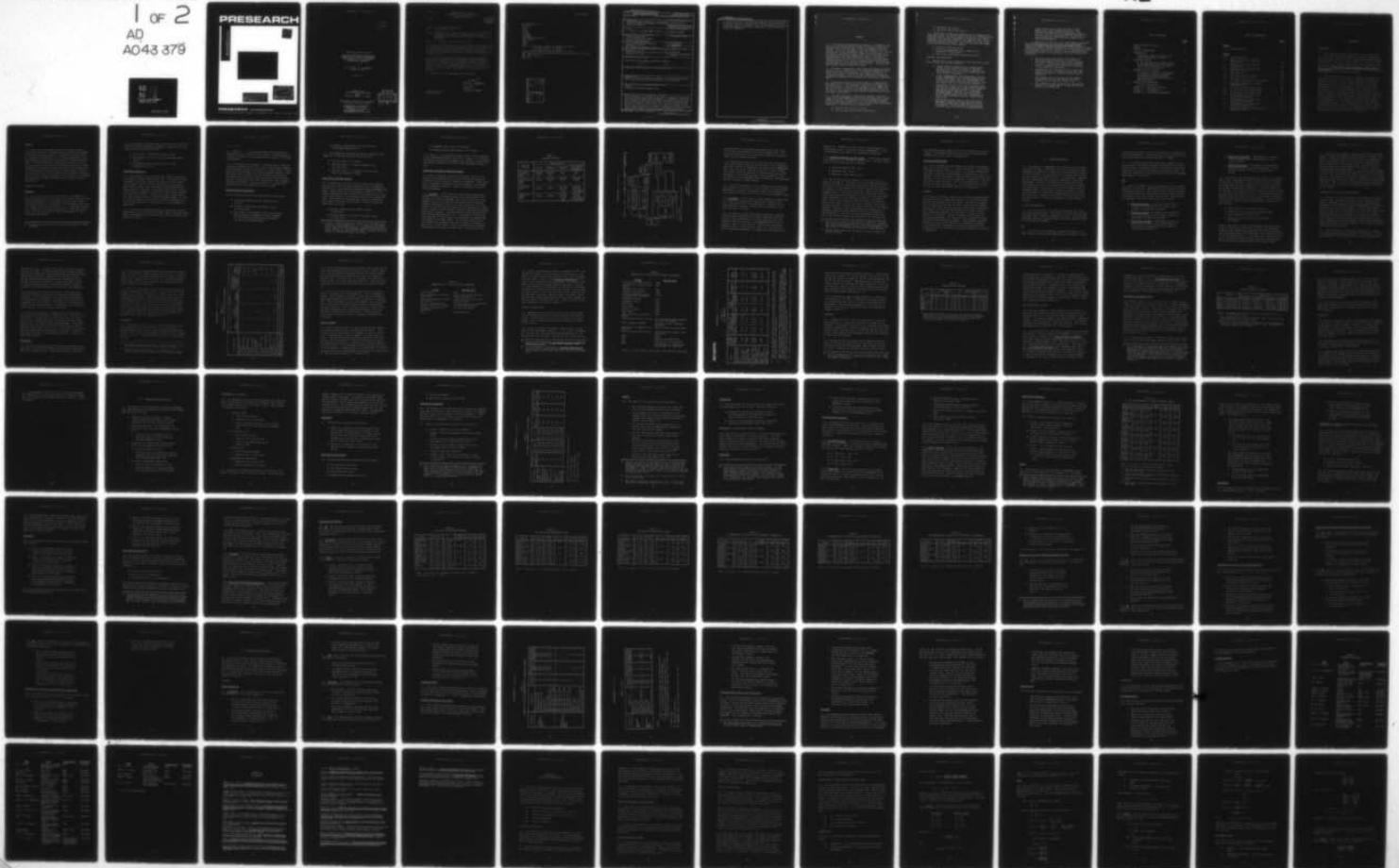
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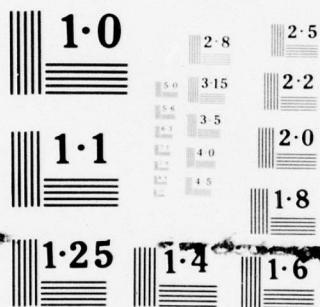
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Technical Report No. 339

GRADUATE PERFORMANCE COMPARISON:
INSTRUCTIONAL SYSTEMS DEVELOPMENT-
TYPE GRADUATES TO TRADITIONAL
INSTRUCTION GRADUATES

by

E. E. Brown, G. A. Adamson
and R. P. Mack

14 July 1977

Prepared for
Chief of Naval Operations
under
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Performance Comparison: Instructional Systems
Development Type Graduates to Traditional Instruction
Graduates"

Encl: (1) Subject Report of 14 July 1977

1. During POM-79 Training and Education Resources Panel (TSP) deliberations, some members expressed concern over the quality of students from ISD-type courses as opposed to students from the same traditionally instructed courses. Enclosure (1) is a report of an analysis conducted to address the question of graduate quality.

2. The report concludes that ISD-type courses produced graduates whose quality of performance was equivalent to graduates of traditionally instructed curricula. Average on board (AOB) reductions associated with the ISD-type courses analyzed are displayed in Table 2.4. It should be noted, however, that the reductions for the AT, AX, AO, and ID courses are now zero (see footnote 2 to Table 2.4 of enclosure (1)).

3. Enclosure (1) is forwarded for information.



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19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Training Instructional Systems Development (ISD)		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This study presents an assessment of the quality of graduates from instructional systems development (ISD)-type courses. Performances of the ISD-type and traditionally instructed (TI) graduates from several courses were compared. Differences and similarities in the TI and ISD-type curricula were determined by comparing course content, attrition rates, average on board and per capita cost to train. The report concludes the following: ISD-type courses produced graduates whose quality of performance was equivalent to the graduates of TI courses; the major difference between ISD-type and TI		

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20. (Cont) > curricula is that ISD-type incorporates theory with practical instruction rather than as separate units; ISD-type curricula with self-pacing often results in a decrease in AOB; ISD-type conversion did not have a consistent impact on attrition; an impact on per capita cost to train could not be identified.

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SUMMARY

1. This report was prepared in response to a request by the Chief of Naval Operations (OP-964D) to assess the quality of graduates from instructional systems development (ISD)-type courses. The term "ISD-type" is used to emphasize that at present there are no graduates from "ISD" courses (i.e., courses developed by the Chief of Naval Education and Training's Instructional Program Development (IPD) field activities using the instructional system development model as outlined in NAVEDTRA 106). The Chief of Naval Technical Training has revised approximately 10 courses using a system-oriented methodology similar to the official NAVEDTRA model. These courses had graduates who were available for analysis. The study was funded under Contract N00014-73-C-0081.
2. The Navy is planning a large-scale implementation of ISD courses, but at present there is no feedback system that evaluates the on-the-job performance of ISD-type graduates. It is believed that the research of this study will provide an interim assessment of the on-the-job performances of ISD-type graduates as compared with graduates of traditional instruction (TI).
3. The primary objective of this study is to compare the performances of the ISD-type and TI graduates from several of the same courses. The secondary objective is to compare the course content, attrition rates, average on board (AOB), and per capita cost to train of the ISD-type courses with the TI courses to demonstrate the differences and similarities in the two types of curricula.
4. The ISD-type courses selected for analysis required a large student throughput to assure the availability of a large sample for study. In addition, ISD-type implementation had to have taken place approximately 2 yr ago so that graduates would have had opportunities to take the Third Class Advancement Examination. The four courses selected were:

- Avionics Technician (AV) Class A
- Aviation Electrician's Mate (AE) Class A

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- Engineman (EN) Class A
- Machinists Mates (MM) Class A.

5. Two cohorts of ISD-type graduates and TI graduates were compiled for each of the four courses using the training records from each school. When TI graduate records were not readily available, the ISD-type graduates were compared with A-school graduates from the same course or all members of those rates within the respective rating. Data were collected for comparison from the following three sources:

- Follow-on training courses
- On-the-job performance marks submitted for promotion to Third Class
- Third Class Advancement Examination scores.

FINDINGS AND CONCLUSIONS

6. The analysis of the comparison of ISD-type and TI graduates yielded the following results:

- a. In the follow-on Advanced First Term Avionics (AFTA) course, the test results of ISD-type graduates were better than the TI graduates but the differences in final course grades were not statistically significant.
- b. In the follow-on Naval Air Maintenance Training Groups (NAMTRAGRU's), the ISD-type graduates had higher final grades than the TI graduates and all other students taking the same courses. The differences were not statistically significant.
- c. The analysis of the on-the-job performance marks submitted for promotion to Third Class indicated that AE and EN ISD-type graduates had higher performance marks than their TI counterparts. The MM graduates, however, had lower on-the-job performance marks than their comparison cohorts. The differences were not statistically significant.
- d. The analysis of the scores on the Third Class Advancement Examination indicated that the AE ISD-type graduates had higher scores than the TI graduates. The EN and MM ISD-type graduates had lower scores for the first examination and

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higher scores on the second and third examinations than their comparison cohorts. The MM ISD-type graduates had significantly lower scores on the first of three examinations analyzed. This was the only comparison that was statistically significant and indicated a higher TI than ISD-type performance.

7. In summary, of 35 ISD-type and TI performance comparisons analyzed and subjected to a 0.01 level of significance, 2 comparisons showed ISD-type graduate performance superior, 1 comparison showed TI graduate performance superior, and 32 showed no performance difference. Therefore, it is concluded that ISD-type graduates from the four class A courses analyzed had performances equivalent to the graduates from the TI version of the course.

- a. The TI and ISD-type curricula are similar for the major topics instructed. TI curricula have instructional units specifically oriented to theory. ISD-type curricula do not consider theory in separate units but rather incorporate it into practical instruction.
- b. Implementation of ISD-type curricula with self-pacing resulted in a decrease in the AOB. The reduction in AOB for the four courses studied totaled 786.
- c. The academic attrition rates for all courses ranged from 0.9% to 5.5%, whereas the total attrition had a range of 1.5% to 11.2%.
- d. The influence in per capita cost to train attributable to a change from TI to ISD-type courses could not be identified.

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I. INTRODUCTION

BACKGROUND

1.1 This study was funded by the Chief of Naval Operations as a portion of the work performed by Presearch Incorporated for the Systems Analysis Division, Manpower/Personnel/Training/Reserve Section (OP-964D), under Contract No. N00014-73-C-0081. The study is an outgrowth of Presearch's interim report of 30 March 1976, Instructional System Development (ISD): Review and Appraisal, which noted that a systematic evaluation of graduates from "ISD-type" courses was needed. NR

1.2 The term "ISD-type" is used throughout the report to emphasize that there are at present no graduates available for analysis from "ISD" courses (courses developed by the Chief, Naval Education and Training (CNET), Instructional Program Development (IPD), and implemented at field activities using the ISD model as outlined in NAVEDTRA 106). Therefore, to assess the quality of graduates from courses that were revised using a systems-oriented methodology and self-pacing (and therefore representative but not necessarily duplicative of ISD course graduates), it was necessary to analyze the graduates from ISD-type courses. The approximately 10 courses revised by the Chief of Naval Technical Training (CNTT) using a systems approach similar to the official NAVEDTRA 106 model are the best courses available for analysis at present.

PURPOSE

1.3 There is no functioning structural feedback system in operation with which to evaluate the postschooling performance of training course graduates. ^{1/} Therefore, there has been no systematic assessment of the on-the-job performance of ISD-type graduates as compared to traditionally instructed graduates. It was believed that research was warranted (even if the best results attainable at the present time must be termed inferential rather than conclusive) because of the large scale of ISD implementation planned for Navy specialized training. The results of this study's research will be useful in furnishing an interim checkpoint assessment of the quality of graduates from self-paced courses developed using a systems-oriented methodology.

OBJECTIVE AND SCOPE

Objective

1.4 The primary objective of this study is to compare the postcourse performance of graduates from several ISD-type courses with the performance of the graduates from the same courses in their pre-ISD-type configuration. Pre-ISD-type courses have been termed traditional instruction (TI). A secondary objective is to compare the curricula content of the TI and ISD-type versions as a basis for rationalizing the differences (if any) in graduate performance.

^{1/} Evaluation systems are currently under development at CNET and CNETS.

1.5 As explained in greater detail in Section III, which discusses the research methodology employed, graduates were compared using the following criteria:

- Performance in follow-on training courses
- Performance on the Third Class Advancement Examination
- Performance marks received at duty stations following training.

Scope and Limitations

1.6 The ISD-type courses available for comparative analysis are limited in number (approximately 10). In addition to that constraint, the courses chosen had to meet several criteria for the study results to be as representative as possible. Specifically, courses from the aviation and nonaviation community should be included. The courses chosen had to have extensive study throughput to provide the large cohorts required for statistical validity. Lastly, the courses chosen had to have been converted from TI to ISD-type approximately 2 yr ago to facilitate data collection and to permit the graduates to have had an opportunity to participate in rate advancement examinations.

1.7 It was determined that the Class A courses for Avionics Technicians (AVs), Aviation Electricians (AEs), Machinists Mates (MMs), and Enginemen (ENs) best met the criteria, and they were chosen for analysis.

METHODOLOGY

1.8 Effectiveness of training programs can be measured by graduate quality, an area of major concern to warfare sponsors. Of specific concern for this report was the quality of the ISD-type graduates.

1.9 An evaluation of graduates of ISD-type courses required either an elaborate survey or the use of existing data compiled on the graduates during certain points in their careers. Since the use of existing data is the most economical approach, ISD-type courses were selected that had the most existing data, and comparison groups were chosen that had the best available records. Appropriate statistical methods were used to compare the ISD-type graduate to the TI graduate or to established standards for his/her respective rate and rating.

Career Points for Evaluation

1.10 The career points for evaluation were the following:

- B-schools immediately after completing the A-schools
- Follow-on courses when reporting to fleet or shore billets
- An average of the graduates' most recent performance evaluations submitted by their commands for the Third Class Advancement Examination (on-the-job performance marks)

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- Graduates' performances on the Third Class Advancement Examination. ^{2/}

1.11 The sequence for choosing the graduate samples in the comparison of ISD-type graduates was as follows:

- ISD-type cohort to TI cohort
- ISD-type cohort to A-school graduates from the same course
- ISD-type cohort to all members of those rates within the respective rating.

Selection of ISD-Type Courses

1.12 The CNTT had identified several courses that complied loosely with an 80% or greater adherence to the Interservice Procedures for Instructional Systems Development (NAVEDTRA 106A) model. These courses were investigated to determine if the students graduating from them could be evaluated at one or more of the career points. Four ISD-type courses were selected for study. Each course had graduates who could be evaluated at two or more of the four career points. The four courses selected were as follows:

- Avionics Technician (AV) School, Class A (C-100-2013)
- Aviation Electrician's Mate (AE Course, Class A (C-602-2012)

^{2/} A-school training prepares the student for job performance and not to take examinations. It is recognized that some of the four career points measure the graduates with written tests. However, if the ISD-type graduate can be evaluated at all four of the career points, then a statement as to the quality of ISD-type training can be made.

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- Engineman (EN), Class A (A-652-0018)
- Machinists Mates (MM), Class A (A-651-0015).

1.13 Table 1.1, the evaluation matrix, gives a quick reference of all evaluations made for this study. Figure 1.1 illustrates the education pipeline the students from the four courses follow from recruit training to the Third Class Advancement Examination.

Selection of Graduate Comparison Groups

1.14 When the ISD-type courses were selected, visits to the schools were scheduled, and, with the help of the respective training offices, data were collected on graduates. Each course and its graduates presented a different problem. The development of comparison groups or cohorts is explained in the following paragraphs.

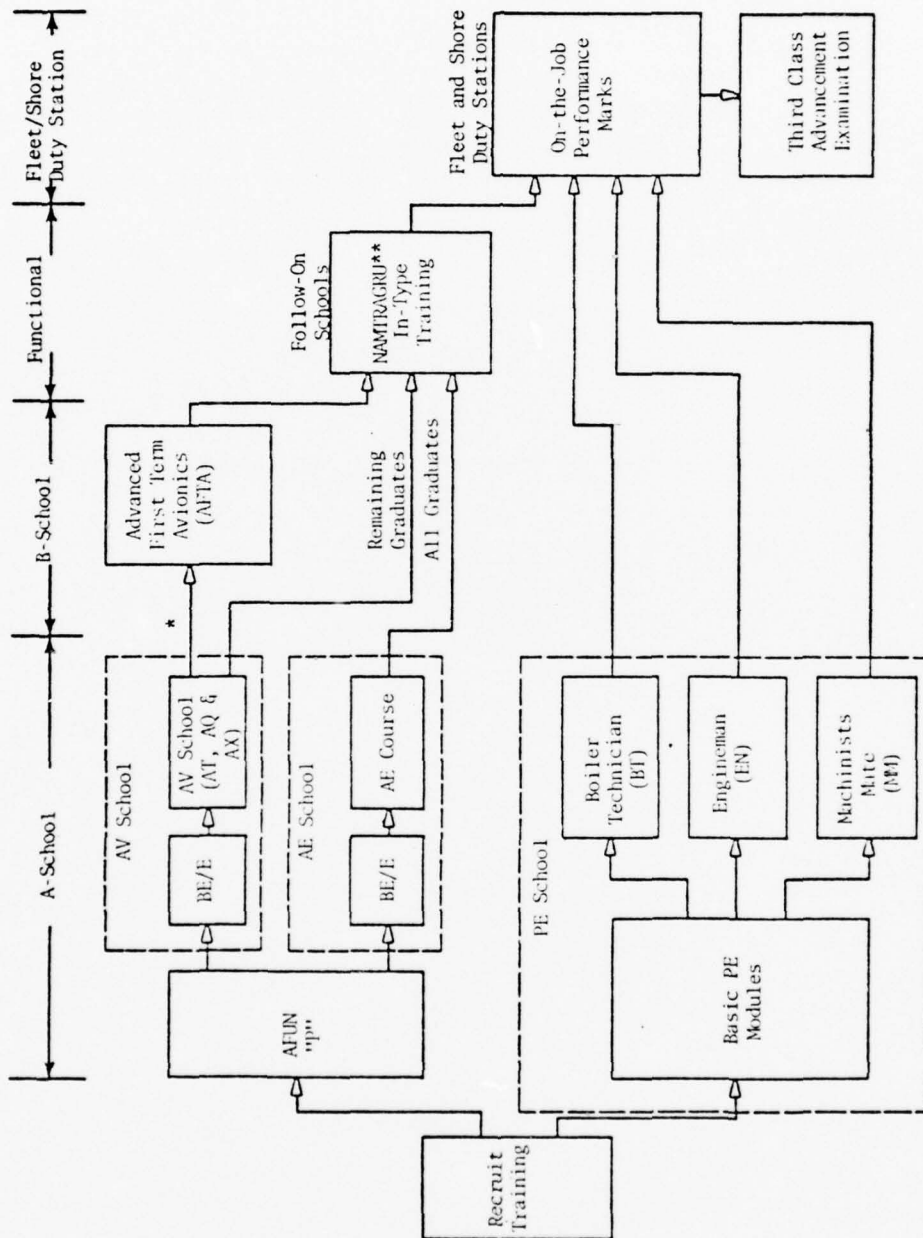
1.15 AV School. The AV school was using the TI method until January 1975, with students graduating as late as March 1975. From March 1975 until September 1975, the AV school was being changed from TI to the ISD-type course that was self-pacing. Students who graduate from the AV course and have a 6-yr obligation are sent to the 26-wk Advanced First Term Avionics (AFTA) Course, Class B (C-100/110-2010), given at Millington, Tennessee, which uses TI methods. The curriculum for this course has not been revised during the past 2 yr. Two cohorts of TI and ISD-type graduates of the AV school were developed to measure their performance in the AFTA school. The TI cohort consisted of 204 students who graduated from the AV course from January to March 1975, and the ISD-type cohort consisted of 335 students who graduated during April and May 1976. The ISD-type cohort

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TABLE 1.1
EVALUATION MATRIX

ISD-Type Courses	Career Points			
	B-School	Follow-on Courses	Performance Marks	Third-Class Advancement Examination
Avionics Technician (AV)	ISD-type versus TI	ISD-type versus TI	No Data	No Data
Aviation Electrician's Mate (AE)	No Courses	ISD-type versus TI	ISD-type versus TI	ISD-type versus TI
Engineman (EN)	No Courses	No Courses	ISD-type versus All E-3 ENs	ISD-type versus EN A-School Graduates
Machinists Mates (MM)	No Courses	No Courses	ISD-type versus All E-3 MMs	ISD-type versus MM A-School Graduates

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* Six-year obligation.

** NAMIRAGRU is a Naval Air Maintenance Training Group.

FIGURE 1.1
STUDENT PIPELINE

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consisted of all AV graduates who completed the AFTA course by the time the data were collected in November 1976. This data were collected so that the cohorts would not include students from the transition period.

1.16 The graduates from the AV school who were not detailed to the AFTA course (those who did not have a 6-yr obligation) were sent to Naval Air Maintenance Training Groups (NAMTRAGRUs) where they were given training on specific aircraft systems. Two cohorts, one with about 500 TI graduates and one with approximately 500 ISD-type graduates, were developed so that performance in the NAMTRAGRUs could be measured. AFTA graduates were not included in these cohorts.

1.17 The ISD-type graduates did not complete the AV schooling early enough to be eligible to take the Third Class Advancement Examination; therefore, performance could not be compared on the examination results or with the on-the-job performance marks.

1.18 AE Course. The AE Class A school changed curriculum from TI to ISD-type training with group pacing in January 1975. All students who started the course after 7 January 1975 received ISD-type training, and those who started before that date received TI training.

1.19 Two cohorts of about 500 graduates each were developed. The AE student pipeline did not have an immediate follow-on B-school course comparable to the AFTA course for AVs, but graduates received training in the NAMTRAGRU before they reported to fleet or shore billets. Each of the cohorts had graduated early in 1975 and were eligible to take the Third Class Advancement Examination in August 1975 and February and

August 1976. Therefore, the AE cohorts could be compared at three career points: follow-on training (NAMTRAGRUs), on-the-job performance, and Third Class Advancement Examination.

1.20 Propulsion Engineering (PE) School. The PE school changed curricula from TI to ISD-type in January 1974. The three courses given at the PE school are the following:

- Boiler Technician (BT), Class A
- Engineman (EN), Class A
- Machinists Mates (MM), Class A.

1.21 The BT course was not included in this study at the request of the CNET. ^{3/} Therefore, only EN and MM graduates were evaluated. ^{4/} The PE school does not have an immediate follow-on B-school, and no appropriate follow-on courses were available for analysis at fleet or shore stations. When the PE school changed from TI to ISD-type training, the school was moved into a new building that was designed to better facilitate the scheduling requirements for the ISD-type curricula. To conserve space, the PE school sent all records of the TI-trained graduates to the record files at St. Louis, Missouri; hence, only ISD-type graduates' records were readily available in the number required. Therefore, ISD-type graduates were compared to all A-school graduates from the same rate and rating taking the same examination. For the on-the-job performance marks evaluation, the ISD-type graduate was compared to all personnel who

^{3/} The BT Class A course in the opinion of CNET (Dr. Scanland) was not a suitable candidate for this research because of the many recent perturbations in that course attributable to the installation of 1,200-psi (84.4-kg/sq-cm) steam equipment.

^{4/} The EN and MM cohorts were screened to avoid including any nuclear students.

had performance marks submitted within the respective rate and rating. Five hundred records of the first EN and MM ISD-type graduates were used to make the comparisons.

Statistical Methodology

1.22 It was assumed that each cohort was normally distributed with mean μ and variance σ^2 . If the two cohorts to be evaluated had equal variances, then the analysis of variance (ANOVA) test was used to determine the difference in performance of the two cohorts. If they had unequal variances, then a two-tailed t-test was used. The F-ratio test was employed to determine if the two cohorts had equal variance. A level of significance, $\alpha = 0.01$, was used to test each hypothesis. For more details on the statistical analysis methodology employed, see Appendix C.

CONTENTS

1.23 Section II briefly contrasts TI and ISD-type methodologies and then provides a comparative analysis of curriculum content for the courses employed in this study. The section concludes with a comparison of average on board, attrition, and student cost for the TI and ISD-type versions of the courses researched. The results of TI and ISD-type student performance, using cohorts drawn from graduates for four Class A courses are presented in Section III. Section IV summarizes the results of the study and presents the conclusions that represent the most significant findings of the research. The personnel contacted during the course of the research are identified in Appendix A, the significant references are listed in Appendix B, and a description of the statistical procedures employed is provided in Appendix C.

II. CURRICULUM REVIEW

2.1 The emphasis in management and systems design has become "objective" oriented. This approach states the goal and then implements the appropriate decision making and designs required to reach the goal. If an organization or action does not have overall "objective" function, then it is eliminated. Education has also implemented the "objective" approach to curriculum development. The Navy, to modernize its educational system in the same way as the civilian educational system, is moving from traditional instruction (TI) to instructional systems development (ISD). This section contrasts the general instructional methods of TI and ISD by evaluating three TI and ISD-type curricula. Average on board (AOB), attrition rates, and per capita costs to train are compared for TI and ISD-type courses.

TI AND ISD COMPARISON

2.2 TI curricula focus on a logical progression from theory to practical applications. ISD focuses on skills and job tasks, with some theory included to support the skills. The following paragraphs describe in greater detail the major characteristics of the TI and ISD concepts.

TI

2.3 TI curricula are frequently designed to progress from basic theory to the practical application of the theory. These

curricula often contain topics of instruction not required for job task performance. The curricula and tests are revised primarily when theories are added, deleted, or changed.

2.4 TI is almost exclusively group paced. Emphasis is on the instructor and his/her personal involvement in the instructional process. The actual method of instruction relies predominantly on lectures with diagram instructional aides. Job tasks are taught during laboratory periods, which are scheduled approximately 1 day a week.

ISD

2.5 ISD is a procedure for assuring application of a systems approach to the design, implementation, and evaluation of the total learning process. This instructional system is designed to teach personnel the knowledge and skills necessary to perform specific jobs with minimal time and cost. ISD curricula are developed in the five-step process that follows:

- Phase One--Analyze. Selection of tasks for instruction by evaluation of job tasks; establishment of performance criterion.
- Phase Two--Design. Development and sequencing of learning objectives and criterion tests; establishment of admission standards.
- Phase Three--Develop. Development of final instructional delivery system; establishment of instructional management plans for resources (instructional materials).

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- Phase Four--Implement. Implementation of instructional management plan; commencement of course and instruction.
- Phase Five--Control. Evaluation of instructional effectiveness and on-the-job performance in fleet and shore billets; revision of instructional system.

2.6 The analysis and design phases are crucial in the development of ISD. These phases identify tasks for which personnel are expected to perform in fleet and shore billets. Learning is accomplished through an emphasis on the active effort of the student rather than the instructor. Learning objectives are the mode used to express precise behavioral objectives prior to selection of learning activities. A learning objective communicates what the learner will be doing in terms of terminal behavior when demonstrating his achievement. To write a learning objective, the following information must be stated for each objective:

- Identification of the overall behavior
- Definition of the important conditions under which the behavior is to occur
- Definition of the criterion of acceptable performance.

Student achievement of each of the learning objectives is measured by administering tests that provide direct assessment of whether the student's performance of the described behavior under the predetermined conditions meets the criterion specified in the learning objectives. A criterion test references a student's achievement to the learning objective criterion rather than rating his performance against others being tested.

2.7 Other features commonly associated with ISD are learning centers, student self-pacing (SP) and the use of computer technology. A learning center contains everything a student normally needs during a course of instruction, including audio-visual devices and instructional aides. The rationale for a learning center is that equipment in the center is readily available when the student needs it. SP refers to that feature in an instructional package that permits the individual student to attain the curriculum's learning objectives at his own learning rate. The computer instructional technology is in two modes: computer-managed instruction (CMI) and computer-assisted instruction (CAI). CMI is involved with student progress through modules and testing; with CAI, the computer provides instruction to the student.

COMPARISON OF TI AND ISD-TYPE CURRICULA

2.8 ISD-type curricula represent an intermediate level application of ISD. The courses studied in this research were revised by CNTECHTRA using a systems-oriented methodology that resembles the ISD approach now being implemented by the Chief, Naval Education and Training (CNET). None of these sample courses' revisions adhered completely to the official ISD model since the model was not available at the time of revision. Therefore the courses researched in this study are referred to as "ISD-type" courses. Specifically, Phase Five, the control, evaluation, and revision phase, has not been implemented. Course evaluations have been conducted, but no formal evaluation system has been established.

2.9 The difference in instructional approaches is evident by comparing several school curricula. The courses' curricula are evaluated by course content before and after instituting

ISD-type curricula. Avionics Technician (AV) School, Aviation Electrician's Mate (AE) School, and the basic Propulsion Engineering (PE) modules for the Engineman (EN) and Machinists Mates (MM) courses are used to compare TI and ISD-type curricula. EN, MM, and Boiler Technician (BT) schools commence with 13 modules of basic PE instruction. The EN, MM, and BT schools' TI course outlines were not available; therefore, the basic PE module curriculum outlines are utilized for the comparison.

2.10 Identification of the format used in outlining course content and mission is necessary to compare TI and ISD-type curricula. The TI curricula of the AV and AE schools and the basic PE modules are designed in syllabus form, introduced by a statement of course mission. The topics for instruction are listed in order of presentation. The ISD-type curriculum outlines contain a series of learning objectives.

2.11 There are constraints in comparing TI syllabus topics to ISD-type learning objective "behavior acts." The term "overall behavior" is sufficient to identify the final main task that is to be learned when there are actually several prerequisite skills that must be learned and performed. The overall behavior acts are listed in the learning objectives, whereas often the theory objectives are not. It was difficult to determine the exact extent to which this has occurred. Learning objectives are used in the following discussion to infer a syllabus when necessary.

AV, Class A

2.12 The AV A course provides the skills and knowledge to perform job entry avionics maintenance tasks common to the Aviation Electronics Technician (AT), Aviation Fire Control Technician

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(AQ) and Aviation Antisubmarine Warfare Technician (AX) ratings. The TI course had an average completion time of 511.7 contact-hours (15.4 wk). The ISD-type course has an average completion time of 485.5 contact-hours (14.6 wk). ^{1/} Of these total ISD-type contact-hours, 38% are spent in the learning center and 62% are spent in the laboratory.

2.13 The TI curriculum data source is "Curriculum Outline for Avionics Technician Course, Class A," dated 7 July 1970. This document is a syllabus preceded by a "course mission," or general learning objective. The ISD-type course data source is "Curriculum Outline for Avionics Technician Course, Class A1," dated February 1976. The ISD-type curriculum outline contains a syllabus in addition to very specific learning objectives. Syllabi were used to compare AV course TI and ISD-type curricula. Although individual topics within these units may differ by content and sequencing, the analysis has been limited to the main unit titles, as compared in Table 2.1.

AE, Class A

2.14 The mission of the AE course is to provide students with the knowledge and skills required to perform maintenance in representative naval aircraft electrical/electronic/instrument systems. The TI course was designed to consist of 478.3 contact-hours (14.4 wk). ^{2/} The ISD-type course is 366.2 contact-hours (11 wk).

^{1/} One contact-period equals 50 min. Eight periods per day for 5 days per week equals 33.33 contact-hours per week.

^{2/} The curriculum included about 112.1 contact-hours (3.4 wk) of BE/E and 366.2 contact-hours (11 wk) of AE curriculum.

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TABLE 2.1
COMPARISON OF TI AND ISD-TYPE AV CURRICULA

ISD-Type Unit	TI Unit				
	Radio Fundamentals	Radar Electronics Fundamentals	Computer Fundamentals	Maintenance Publications and Administration	Hours/ISD-Type Unit
Intermediate electronics	X	X	X	--	33.25
AM communications system	X	--	--	--	167.25
FM communications system	X	--	--	--	10.0
Computer systems	--	--	X	--	71.5
Airborne search radar systems	--	X	--	--	138.5
IFF systems	--	X	--	--	3.0
Fire control radar system	--	X	--	--	2.0
Airborne navigation system	X	--	--	--	3.0
Maintenance activity procedure	--	--	--	X	57.0
Contact-hours per TI unit	231.7	123.3	100.0	56.7	--
Total TI, hr	511.7				
Total ISD-type, hr	--				485.5

2.15 The TI curriculum data source used was "Curriculum Outline for Aviation Electrician's Mate School, Class A," dated 9 April 1974. The ISD-type curriculum data source was "Course Outline for Aviation Electrician's Mate Course, Class A1," dated 20 February 1976. The TI outline is a syllabus; the ISD-type outline is a series of course learning objectives. The major units instructed for TI and ISD-type curricula are compared in Table 2.2.

2.16 The TI curriculum differs from ISD-type in two topical areas: introduction and troubleshooting. The TI introductory topics, such as safety, hand tools, and designs and schematics, have been eliminated from the ISD-type curriculum as a separate unit. These introductory topics are presumed to be incorporated into the ISD-type curriculum, without necessitating separate learning objectives. The TI syllabus contains a sentence stating that troubleshooting is emphasized throughout the course. The ISD-type learning objectives specify troubleshooting as a main unit in addition to being a knowledge requirement for each topic.

Basic PE Module

2.17 The PE school provides the skills and knowledge required to continue training in the ratings of EN, MM, and BT. Each of these courses is preceded by 13 modules of basic PE instruction. These modules are used to compare TI and ISD-type curricula. The TI curriculum consisted of a minimum of 30 hr per week for 9 wk of instruction. The curriculum outline states the students should receive a combination of classroom and practical work daily. The self-paced 13-module ISD-type curriculum is to be completed in approximately 126 contact-hours (3.7 wk). ^{3/}

^{3/} Each class day has about 6.75 contact-hours.

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TABLE 2.2
COMPARISON OF TI AND ISD-TYPE AE CURRICULA

<u>TI Unit</u>	<u>ISD-Type Unit</u>
Introduction	None
Basic electronics applicable to aircraft	Basic electrical/electronic/mechanical repair
Electrical machinery devices and circuits	Signal tracing of basic electronic circuits
Aircraft instruments and flight stabilization system	Aircraft electrical, electronic, and instrument systems
Aircraft system and line maintenance	Aircraft maintenance
None	Troubleshooting

2.18 The TI curriculum data source is NAVPERS 93799. ^{4/} The EN, MM, BT courses' TI curricula were not available for this study. In lieu of these curriculum outlines, basic PE course data were used. The test book Propulsion Engineering ^{5/} was used to infer ISD-type curriculum content. By using this test book, the main units of study could be determined. However, it did not permit the determination of the amount of introductory material provided to the ISD-type student. The exclusion of certain topics in the test book infers their deletion from the ISD-type curriculum. However, some of the theory topics may have been incorporated into the ISD-type units without requiring specific learning objectives. Topics included in the basic PE modules are listed in Table 2.3.

AVERAGE ON BOARD (AOB)

2.19 Implementation of ISD-type curricula has had an impact on course length and AOB as a result of SP and curriculum revision. The revisions of curricula have reduced the course content solely to that material that is necessary to perform a job or skill.

2.20 Table 2.4 provides throughput, course length, and AOB data for the four sample courses, i.e., AV, AE, EN, and MM and six curricula (pre- and post-ISD-type implementation). The MM rating has two curricula: the 600-psi (42.2-kg/sq-cm) and

^{4/} Bureau of Naval Personnel, Curriculum for Basic Propulsion Engineering, Class A, NAVPERS 93799, September 1969.

^{5/} U.S. Government Printing Office, Propulsion Engineering, "Individualized Learning System," Third Edition (Progress Checks, Modules One Through Thirteen), 650-490/1402, August 1975.

TABLE 2.3
COMPARISON OF TI AND ISD-TYPE BASIC PE CURRICULA

<u>TI Unit</u>	<u>ISD-Type Unit</u>
Introduction, indoctrination	None
Introduction to marine power plants	None
Introduction to boilers	None
Combustion principles	None
Internal combustion engines (including gas turbines)	None*
Mathematics review	None
Mechanical theory	None
Metallurgy	None
Fluid theory	None
Electrical theory	None
Heat theory	None
Logs, blueprints, and telephones	None
Measuring and control devices	Precision measuring instruments and technical manuals
Power transfer equipment	Turbines (steam), couplings, and gears
Hand tools, instruments, and materials	Metal fasteners and hand tools
Valves, piping, and fittings	Valves; packing, gaskets, and insulation
Pumps	Pumps
None	Bearings and lubrication
None	Strainers and oil purifiers
None	Low-pressure air systems and low-pressure air compressor

* There is no gas turbine instruction in the ISD-type curriculum.

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TABLE 2.4
AOB COMPARISON

Course	FY 1977 Planned Through- put	Average No. Days Enrolled 1/		Average on Board		Reduction in AOB, %	AOB Impact
		TI	ISD-type	TI	ISD-type		
Avionics Tech- nician (AT, AQ, AX)	2,538	102.0	91.3 <u>2/</u>	709.2	634.8	-10	74.4
Avionics Tech- nician (TD)	479	70.0	65.6 <u>2/</u>	91.9	86.1	-6	5.8
Aviation Elec- trician's Mate (AE)	1,866	77.0	77.0	393.6	393.6	0	0
Engineman (EN)	1,698	77.0	42.0	358.2	195.4	-45	162.8
Machinists Mates (MM), 600 psi (42.2 kg/sq cm)	2,226	84.0	42.0	512.3	256.1	-50	256.2
Machinists Mates (MM), 1,200 psi (84.4 kg/sq cm) <u>3/</u>	2,832	84.0	47.0	651.7	364.7	-44	287.0

1/ Comprises the interval from the first day to graduation day (i.e., 5 days instruction and 2-day weekends). The figures are based on actual training records and may or may not equal programmed curriculum lengths.

2/ Number of days enrolled was computed using the monthly averages from the past year (May 1976 through April 1977). Before March 1977 the complete AV curriculum could not be taught because required equipment was not available. With the addition of this equipment in March 1977, it is expected the AT, AQ, AX and TD courses will lengthen, the AOB will increase, and AOB impact may approach zero.

3/ The 1,200-psi (84.4-kg/sq-cm) Machinists Mates Course was not conducted until June 1976.

the 1,200-psi (84.4-kg/sq-cm) engine curricula. The AV course trains four ratings: AT, AQ, AX, and TD. The duration of AT, AQ, and AX courses are identical; the TD course is shorter than the AT, AQ, and AX courses. Implementation of ISD-type curricula resulted in a decrease in course length for five of the six curricula. Due to a lack of funds, the AE course was the only course of the six that did not develop an SP curriculum, and the course length remained at 11 wk.

2.21 A reduction in course length resulted in a reduction of the projected FY 1977 AOB. A significant financial savings in training costs can occur as a result of the reduction in AOB caused by ISD-type SP implementation. The reduction in length of the four curricula had the effect of reducing 786 student billets. ^{6/}

ATTRITION

2.22 Academic attrition rates are evaluated for TI and ISD-type curricula to (a) quantify the degree of change and (b) determine if the academic attrition is in reasonable accordance with Navy expectations. Table 2.5 presents the attrition rate data for the TI and ISD-type AV, AE, EN, MM, and basic PE curricula. Both academic and nonacademic attritions are displayed by attritions per thousand.

2.23 The data reveal an increase in the academic attrition rate for ISD-type curricula for the AV and basic PE courses, a decrease for the EN and MM courses, and no change for the AE course. Therefore, an ISD-type conversion did not have a

^{6/} The AOB reduction of 80.2 for the AV school was of a temporary nature because of a shorter than planned course caused by absence of equipment.

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TABLE 2.5
ATTRITIONS PER THOUSAND

Course	TI Course			ISD-Type Course		
	Academic	Non-academic	Total	Academic	Non-academic	Total
AV	32	47	79	55	56	112
AE	20	70	90	20	30	50
Basic PE	3	39	42	9	63	72
EN*	1	14	15	1	14	15
MM*	2	22	24	0	64	64

* The attritees listed for the basic PE module are from the preliminary 3-wk PE curriculum for BT, EN, and MM students. The attritees from the EN and MM courses are drops that occurred subsequent to the basic PE module.

consistent impact on attrition. The BT, EN, and MM courses are preceded by a 3-wk module of basic PE. The attritees listed for the basic PE module are from the 3-wk module. The attritees from the EN and MM courses are drops that occurred subsequent to the basic PE module. It appears that in the transition to ISD-type curricula, the academic attrition for the EN and MM courses was shifted to the basic PE module. The academic attrition rate at EN, MM, and basic PE courses is less than 1%, which seems to be a reasonable rate. The 2% and 5% academic attrition rates for the AE and AV courses, respectively, are also reasonable rates for academic attrition.

PER CAPITA COST TO TRAIN

2.24 The major emphasis of the research in this study is in analyzing the quality of students graduating from the four sample Class A courses in the ISD-type mode as compared to the TI mode. This section, however, has addressed other comparative aspects: curriculum content, AOB, and attrition. The section concludes with an analysis of the cost trends for the four sample courses covering the FY 1973 to 1976 period.

2.25 At the present time, two course cost reports are available for analysis. Both are compiled by CNTECHTRA. The first, compiled monthly, is known as the Monthly School Cost Report. This report does not include investment costs or all military personnel allowance/benefit costs. Therefore, while it is timely, it understates actual costs significantly. The second report, Per Capita Cost to Train, has investment costs and all military personnel allowance/benefit costs included. While it is the most complete data currently available for analysis, it does not include all equipment costs (training equipment is categorized into many classifications and budgets, which

encumbers per capita training cost accounting), nor does it include most computer costs. Per Capita Cost to Train also has a limitation in its use of year-to-year cost trend analysis in that it is computed only on an annual basis. As CNTECHTRA completely amortizes investment costs in the year in which they occur, year-to-year per capita cost perturbations occur that are attributable to the uneven flow of investment. ^{7/}

Cost Data for Sample Courses

2.26 The per capita cost to train for the four sample courses used in this analysis is shown in Table 2.6. A major component in the per capita cost is student MPN. Three of the four courses had a reduction in AOB after the course was changed to an ISD-type, and one course had no change in AOB (see Table 2.4). Therefore, the student MPN cost component should provide a downward bias in the per capita cost to train. On the other hand, the data in Table 2.6 are in current dollars and therefore contained an upward bias attributable to inflation. The investment flow contains high-value equipment costs and construction costs; these costs were components particularly noticeable in the FY 1976 EN and MM A course costs because of improvements made in PE facilities that year.

2.27 It can be seen in Table 2.6 that the trends in per capita cost to train for the four sample courses varied widely. The

^{7/} The limitations of the present costing procedures are recognized, and CNET has promulgated CNET Inst. 7310.2A (Subject: CNET Training and Education Costing and Report System (TAECARS)) to improve costing procedures. It is anticipated that the improvement effort may take several years to become fully implemented. In the interim it will be difficult to isolate, for purposes of analysis, any one cost influence such as ISD unless some modification is made to present cost procedures.

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TABLE 2.6
PER CAPITA COST TO TRAIN

Course	Cost, \$			
	FY 1973	FY 1974	FY 1975	FY 1976
AE A-1 (C-602-2012)	5,966.73	5,205.64	3,302.46*	3,451.80
AV A-1 (C-100-2013)	4,193.44	3,975.74	4,373.38	4,405.22*
EN A-1 (A-652-0018)	1,919.06	1,085.55*	852.33**	2,208.36
MM A-1 (A-651-0015)	1,656.18	1,508.33*	852.33**	1,528.20

Source: CNTECHTRA, "Per Capita Cost to Train Reports: FY 73-FY 76," CNET N-6213.

* The commencement time when all students under instruction were matriculating in an ISD-type course.

** In FY 1975, the EN A and MM A courses were costed aggregately because of the basic PE module common to both. Therefore, the costs were shown to be the same.

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two aviation courses increased nominally in FY 1976 after conversion to ISD-type, but the increase was in the range that could be attributed to inflationary bias. The two PE courses increased in FY 1976 compared to FY 1974 (when the courses were converted to ISD-type) but the increases differed greatly in magnitude--EN A course cost more than doubling (presumably because of investment construction costs), while MM A course cost remaining almost unchanged.

2.28 The present cost data system does not permit any high confidence conclusion to be made regarding the effect on per capita cost attributable to a change in a given course from TI to ISD-type.

CONCLUSION

2.29 The TI and ISD-type curricula are similar for the majority of the topics instructed. While it is not possible to determine if the amount of theory taught is different, it appears that the emphasis on theory has changed. TI curricula commenced with a great deal of theory. ISD-type curricula do not teach theory as separate units but rather incorporate theory with practical skills.

2.30 Implementation of ISD-type curricula has resulted in a decrease in training AOB. The reduction in training for the four courses studied total 786 man-years.

2.31 Academic attrition rates varied in ISD-type curriculum. An increase in the academic attrition rate for the ISD-type curriculum occurred in the AV and basic PE courses, a decrease occurred for the EN and MM courses, and no change occurred in the AE course. The academic attrition rates for all courses were in the 0.9% to 5.5% range.

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2.32 The influence in per capita cost to train attributable to a change from TI to ISD-type could not be isolated. Therefore, no conclusion can be made based on cost data in the present reports.

III. GRADUATE QUALITY ANALYSIS

3.1 The analysis of the instructional systems development (ISD) type graduates was conducted at four points and comparisons were made as follows:

- a. Immediate follow-on B-school: ISD-type versus traditional instruction (TI) Avionics Technician (AV), Class A school graduates
- b. Follow-on functional training at Naval Air Maintenance Training Group (NAMTRAGRU) schools for:
 - 1. ISD-type versus TI graduates for AV
 - 2. ISD-type versus all other students in the same NAMTRAGRU courses
- c. Fleet and shore duty on-the-job performance marks, when recommended for Third Class:
 - 1. ISD-type versus TI for AEs
 - 2. ISD-types versus all candidates from the respective rate and rating, for Engineman (EN) and Machinists Mates (MM)
- d. Third Class Advancement Examination:
 - 1. ISD-type versus TI graduates for AEs
 - 2. ISD-type versus all A-school graduates from the same course, for ENs and MMs.

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PERFORMANCE IN B-SCHOOL

3.2 The graduates of the Avionics Technician (AV) School who have 6-yr obligations are sent to the Advanced First Term Avionics (AFTA) Course, Class B (C-100/111-2010). AFTA students are graded in four areas:

- a. Practical work
 - 1. Nine grades assigned
 - 2. Comprises 8% of final grade
 - 3. Grade is based on quality of work, safety, completeness and time required to complete work
- b. Performance tests
 - 1. Nine grades assigned
 - 2. Comprises 19% of final grade
 - 3. Graded in the same manner as the practical work
- c. Written tests
 - 1. Thirteen grades assigned
 - 2. Comprises 63% of final grade
- d. Comprehensive examination
 - 1. Comprises 10% of final grade
 - 2. Given at the end of the course.

3.3 The quality of graduate performance is related to the quality of student input to that curriculum. If student input

quality changes, then it would be expected that graduate performance would also change. To determine if student input quality changed, the Basic Test Battery (BTB) scores required for selection to the AV school were compared for the TI and ISD-type cohorts. The two BTB aptitude tests used for AV Class A entrance screening are the Arithmetic Reasoning (ARI) and Electronics Technician Selection Test (ETST). The required score for selection is 171 or higher (ARI and 2 ETST).

Hypotheses

3.4 The hypotheses tested were as follows:

- There was no difference between the mean scores of the ISD-type and TI-trained students in the AFTA course. This hypothesis was tested on each of the five test scores (practical work, performance test, written test, comprehensive examination, and final course grade).
- There was no difference in the quality of the ISD-type and TI students selected for the AFTA course.

Data and Data Collection

3.5 The following data were collected on each student:

- Practical work raw scores
- Performance test raw scores
- Written test raw scores
- Comprehensive examination raw score

- Final course grade
- BTB scores, including ARI and ETST.

Statistical Procedures

3.6 The variances of the ISD-type and TI cohorts were compared using the F-ratio test. The variances were found to be unequal. The two-tailed t-test was used to test the hypotheses. A significance level of $\alpha = 0.01$ was selected as the critical decision value (see Appendix C for details).

3.7 Table 3.1 illustrates the results of the analysis:

- a. Column 1 identifies the test categories
- b. Column 2 shows the percentage of the final course grade
- c. Column 3 lists the means, standard deviations, and sample sizes of the ISD-type cohort
- d. Column 4 lists the means, standard deviations, and sample sizes of the TI cohorts
- e. Column 5 shows the t-statistic
- f. Columns 6 and 7 show that significance at the $\alpha = 0.01$ and $\alpha = 0.05$ levels is either confirmed or negated. ^{1/}

^{1/} The t-values at the top of Columns 6 and 7 designate the point at which the statistic would become significant at that level. If the absolute value of the t-statistic is less than the value at the top of the α columns, then there is no significant difference at the mean grade of the two cohorts. If it is equal to or greater than the t-value, there is a significant difference.

TABLE 3.1
AV STUDENT PERFORMANCE IN AFTA COURSE

Category	Percentage of Final Grade	ISD-Type $\frac{1}{-}$	TI $\frac{2}{-}$	t Statistic	$\alpha = 0.01$ Level (t = 2.60)	$\alpha = 0.05$ Level (t = 1.97)
Final course grade	100	M = 76.53 S = 5.54	M = 75.93 S = 5.34	1.24	No	No
Comprehensive examination	10	M = 69.14 S = 6.07	M = 68.48 S = 5.46	1.30	No	No
Performance test	19	M = 82.69 S = 5.18	M = 80.55 S = 6.38	4.05	Yes	Yes
Written test	63	M = 75.30 S = 6.94	M = 75.04 S = 6.26	0.44	No	No
Practical work	8	M = 80.91 S = 4.36	M = 79.70 S = 3.75	3.43	Yes	Yes
Basic Test Battery 3/	NA	M = 195.70 S = 13.68	M = 192.90 S = 13.53	2.22	No	Yes

Note: M is mean and S is standard deviation.

$\frac{1}{-}$ Total of 335 students.

$\frac{2}{-}$ Total of 204 students.

$\frac{3}{-}$ BTB score = ARI + 2 ETST.

Results

3.8 The results of this portion of the study were:

- a. The ISD-type students had higher mean scores than the TI-trained students on all four test areas.
- b. In the examination areas of performance tests and practical work, the mean scores of the ISD-type students were significantly better than those of the TI-trained students. ^{2/}
- c. The ISD-type students scored higher on the 13 written tests and the comprehensive examination (but not statistically higher).
- d. The ISD-type students had higher mean scores on the final course grade (but not significantly higher).
- e. The ISD-type students did significantly better on two of the four test areas (practical work and performance tests) that comprise the final course grade; however, they did not do significantly better on the final course grade. ^{3/}
- f. The BTB scores show that student input to the ISD-type course had higher scores. ^{4/}

^{2/} This may be because of the difference in curriculum content emphasis between TI and ISD-type curricula. The ISD-type curriculum was developed by defining those job skills the graduates are required to know to perform the day-to-day assignments in fleet or shore billets. As a result, the ISD-type curriculum puts greater stress on the hands-on approach to learning job skills.

^{3/} Note that the two test areas only accounted for 27% of the final course grade.

^{4/} The difference was not significant at the $\alpha = 0.01$ level. There was a significant difference at the $\alpha = 0.05$ level.

Conclusions

3.9 The conclusions for this portion of the study were based on significance level of $\alpha = 0.01$. They are as follows:

- There was no significant difference between the performances of the ISD-type students and the TI students in the AFTA course
- There was no significant difference between the ISD-type and TI students' BTB cohort scores.

PERFORMANCE IN FUNCTIONAL FOLLOW-ON SCHOOLS

3.10 When Avionics Technicians (AVs) and Aviation Electrician's Mates (AEs) are assigned to aircraft squadrons in the fleet after completing A-school training at Millington, Tennessee, they are given additional training at one of the Naval Air Maintenance Training Groups (NAMTRAGRUs). This portion of the study presents the analysis of the ISD-type and TI graduates' performances at functional follow-on schools.

Hypotheses

3.11 The hypotheses tested were as follows: 5/

5/ Two hypotheses were used to facilitate testing: (a) ISD-types against TI graduates and (b) ISD-types against all other non-TI students. The reason for dual testing is that NAMTRAGRUs offer many courses. The original Class A school cohorts became very fragmented at this point in the training pipeline (i.e., under 10, as can be seen in Table 3.2). Therefore, the ISD-types were compared with both the TI group and with all others.

- There was no difference between the mean final grades of the ISD-type and TI students in the NAMTRAGRU courses.
- There was no difference between the mean final grade scores of the ISD-type graduates and other students in the same NAMTRAGRU courses.

Data and Data Collection

3.12 To keep the cost of data collection to a minimum, two east coast NAMTRAGRUs were selected. They were Oceana, Virginia, where the required data could be collected during a 1-day, on-site visit and Cecil Field, Florida, where the information was in a computerized data base from which it could be extracted.

3.13 AV and AE Cohorts. The original cohorts collected at Millington included Marine, foreign, and reserve students along with Navy students. When these non-Navy students were deleted, the cohorts were approximately reduced as follows:

- AV (ISD-type): 500 to 438
- AV (TI): 700 to 634
- AE (ISD-type): 500 to 346
- AE (TI): 500 to 392.

3.14 Oceana Data. The final course grades for each member of the four cohorts were collected from the NAMTRAGRU course graduation rosters. It was discerned that only four courses provided sufficiently large sample sizes for comparison. The four courses were:

- a. ARN-52/86-TACAN Receiver, Intermediate Maintenance (C-102-3034) (BNG)
- b. A-6A/KA-6D/A-6E-Electrical Systems, Organizational Maintenance (C-602-3766) (AHL)
- c. F4B/J-Basic Aviation Electrical System (C-602-3821) (FEG)
- d. F4B/J-Advanced Aviation Electrical System (C-602-3822) (FEH).

3.15 The graduation rosters for these four courses contained the final grades for all students who completed these courses from September 1974 through November 1976. Three samples were developed for each course: ISD-type, TI, and all other students who had completed the same course. Then two comparisons for each course were made: ISD-types were first compared with the TI students, and then the ISD-types were compared with all other students completing the same course.

3.16 Cecil Field Data. The social security numbers of the graduates in the four cohorts were used to extract the final grades and course numbers from the data base at Cecil Field. The two AV cohorts had five ISD-type and 15 TI graduate records. The five ISD-type graduates had not received training in the same courses taken by the TI graduates; therefore, no performance comparison could be made. The two AE cohorts had 21 ISD-type and 11 TI graduate records. One course had records for both ISD-type and TI students. However, only two students of each type had taken the same course, and no performance comparison could be made. Therefore, Cecil Field data could not be used to provide a sample for NAMTRAGRU analysis.

Statistical Procedures

3.17 Each comparison group, i.e., ISD-type versus TI and ISD-type versus others, passed the F-ratio test for equal variances, and the analysis of variance (ANOVA) test was used to test the hypotheses. The significance level of $\alpha = 0.01$ was used to determine the results (see Appendix C for details).

3.18 Table 3.2 indicates the results of the analysis:

- Column 1 identifies the type of comparison and the course number (course titles are identified in the footnotes)
- Column 2 gives the means, standard deviations, and sample sizes of the ISD-type samples
- Column 3 presents the means, standard deviations, and the sample sizes of the TI or "all other" student samples taking that course
- Column 4 lists the ANOVA F-ratio statistic
- Columns 5 and 6 present the F-value for the level of significance at $\alpha = 0.01$ and $\alpha = 0.05$, and indicates whether the significance at the $\alpha = 0.01$ and $\alpha = 0.05$ levels is confirmed or negated.

Results

3.19 The analysis of the courses given at NAMTRAGRU, Oceana, consisted of 29 ISD-type and 18 TI graduates. ^{6/} The sample

^{6/} These students comprise the survivors of the initial large cohorts taken at Millington (see Paragraph 3.13). Since it was not possible at Millington to identify the NAMTRAGRU to which AV and AE Class A graduates had been assigned, it was not feasible to ensure a larger sample at NAMTRAGRU, Oceana, by "seeding" the initial cohorts.

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TABLE 3.2
AV AND AE PERFORMANCE AT OCEANA NAMTRAGRU SCHOOL

Category	ISD-Type	TI or Others 1/	ANOVA F-Ratio	$\alpha = 0.01$ Level	$\alpha = 0.05$ Level
ISD-type vs TI-- AV(AT) 2/	M = 74.77 S = 1.16 N = 3	M = 80.46 S = 5.38 N = 5	3.97	No F = 13.74	No F = 5.99
ISD-type vs others-- AV(AT) 2/	M = 74.77 S = 1.16 N = 3	M = 83.44 S = 5.98 N = 59	6.21	No F = 7.08	Yes F = 4.00
ISD-type vs TI-- AE 3/	M = 81.54 S = 5.92 N = 14	M = 77.43 S = 7.15 N = 5	1.60	No F = 8.40	No F = 4.45
ISD-type vs others-- AE 3/	M = 81.54 S = 5.92 N = 14	M = 80.52 S = 6.82 N = 162	0.29	No F = 6.76	No F = 3.89
ISD-type vs TI-- AE 4/	M = 89.30 S = 4.92 N = 7	M = 83.20 S = 4.50 N = 5	4.80	No F = 10.04	No F = 4.96
ISD-type vs others-- AE 4/	M = 89.30 S = 4.92 N = 7	M = 89.28 S = 5.27 N = 128	0	No F = 6.81	No F = 3.91
ISD-type vs TI-- AE 5/	M = 89.72 S = 2.25 N = 5	M = 84.73 S = 6.53 N = 3	2.65	No F = 13.74	No F = 5.99
ISD-type vs others-- AE 5/	M = 89.72 S = 2.25 N = 5	M = 89.64 S = 6.03 N = 103	0	No F = 6.81	No F = 3.92

Note: M is mean, S is standard deviation, and N is number.

- 1/ All other students who completed the course.
- 2/ ARN-52/86 TACAN Receive, Intermediate Maintenance (Course No. C-102-3034) (BNG).
- 3/ A-6A/KA-6D/A-6E Electrical Systems, Organizational Maintenance (Course No. C-602-3766) (AHL).
- 4/ F4B/J Basic Aviation Electrical System (Course No. C-602-3821) (FEG).
- 5/ F4B/J Advanced Aviation Electrical System (Course No. C-602-3822) (FEH).

sizes for each course are considered to be too small to make a decision as to the comparative quality of the ISD-type graduates. However, the results of the analysis are presented so it may be considered with the data from the other three career points. The results were:

- a. Only three ISD-type graduates (AVs) took the first course shown in Table 3.2. These three students had lower mean scores than the TI students and lower mean scores than all other students who completed the same course.
 1. The difference was not significant at the $\alpha = 0.01$ level for either comparison.
 2. The difference was significant at the $\alpha = 0.05$ level for the ISD-type and Others comparison.
- b. The results from the analyses of the other three NAMTRAGRU courses indicated the ISD-type graduates (AEs) had higher mean scores than the TI graduates and higher mean scores than all other students who completed the same course.
 1. The differences were not significant at the $\alpha = 0.01$ level.
 2. The differences were not significant at the $\alpha = 0.05$ level.

Conclusions

3.20 The conclusions for this portion of the study were based on a significance level of $\alpha = 0.01$. They were:

- There was no difference between the mean final grades of the ISD-type and TI graduates taking the same NAMTRAGRU courses.
- There was no difference between the mean final grades of the ISD-type and all other students who completed the same NAMTRAGRU courses.

PERFORMANCE IN FLEET AND SHORE BILLETS AND ON THIRD CLASS
ADVANCEMENT EXAMINATION

3.21 The quality of ISD-type graduates can be evaluated by comparing their on-the-job performance marks and scores on the Third Class Advancement Examination with TI graduates. When class rosters of TI graduates were not available at the school (because of records disposal), ISD-type graduates were compared with all A-school graduates from the same courses. If the data did not identify A-school graduates then the ISD-type students were compared with all members of that rate within the respective rating. The three Class A courses selected for this portion of the study were:

- Aviation Electrician's Mate (AE)
- Engineman (EN) (nonnuclear students)
- Machinists Mates (MM) (nonnuclear students).

3.22 The Aviation Electrician (AE) school had records on both ISD-type and TI graduates, and two cohorts were formed. The school records included the BTB scores so that a comparison of the quality of students selected for the AE course could also be made.

3.23 The Engineman (EN) and Machinists Mates (MM) schools only had ISD-type records available. Therefore, the ISD-type graduates' third class examination scores were compared with all A-school graduates from the same school. The data for the on-the-job performance marks did not identify the A-school graduates, so the ISD-type graduates were compared with all E-3s within the respective rating.

Hypotheses

3.24 The hypotheses tested for the on-the-job performance marks analysis were:

- There is no difference between the mean on-the-job performance marks of the ISD-type and TI graduates from the AE school
- There is no difference between the mean BTB scores of the ISD-type and TI graduates selected for the AE school
- There is no difference between the mean on-the-job performance marks of the EN, ISD-type graduates, and all EN E-3s recommended for promotion to Third Class
- There is no difference between the mean on-the-job performance marks of the MM, ISD-type graduate, and all MM E-3s recommended for promotion to Third Class.

3.25 The hypotheses tested for performance on the Third Class Advancement Examinations were:

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- There is no difference between the mean scores on the Third Class Advancement Examination of the ISD-type and TI graduates of the AE course.
- There is no difference between the average performances on the Third Class Advancement Examination of the ISD-type and all EN, A-school graduates from the EN course.
- There is no difference between the average performances on the Third Class Advancement Examination of the ISD-type and all MM, A-school graduates from the MM course.

Data and Data Collection

3.26 The Naval Education and Training Information Systems Activity (NETISA) data base at Pensacola, Florida, contained data on the Third Class Advancement Examination results. Each graduate's social security number was used to extract the following data:

- On-the-job performance mark 7/
- Raw score on the examination
- Standardized score on the examination.

The Systems Advancement Evaluation and Analysis Division, Naval Education and Training Program, Ellyson Field, Pensacola, Florida, furnished the averages, standard deviations, and sample sizes

7/ When personnel are recommended to take the Third Class Advancement Examination, their command must submit an average of the candidate's last several enlisted performance evaluations. This average, or on-the-job enlisted performance mark, provides the best statistical measure of performance.

of on-the-job performance marks for candidates taking each examination, by rate and rating. They also furnished the distribution of standard scores for A-school candidates by rate and rating for each examination.

3.27 AE. The original cohorts of about 500 each had Marine, foreign, and reserve students. When these students were deleted from the cohorts, the TI cohort contained 392 graduates, and the ISD-type contained 346 graduates. Both AE cohorts graduated in early 1975, and data from the August 1975, February 1976, and August 1976 test periods provided information on 45% of each cohort or 153 ISD-types and 175 TI graduates for comparison.

3.28 EN and MM. The EN and MM ISD-type graduates graduated in early 1974. Each cohort had several graduates take the examination in August 1974, but comparison data were not available from Ellyson Field for that test period. The NETISA data base was missing data on the February 1975 test period. Complete data for comparison were available from both sources for August 1975, February 1976, and August 1976 examinations. These three test periods contained 249 EN, ISD-type graduates (50% of the initial cohort) and 201 MM ISD-type graduates (40% of the original cohort).

3.29 Third Class Advancement Examination. The raw and standard scores were used to assess performance on the Third Class Advancement Examination. The raw score indicated how well the candidates did on the examination. When the raw scores were standardized, the performance of all of the other personnel in that rating (taking the same examination) influenced the computation of each candidate's standard score. Standard scores were used to compare students on the same examination, and raw scores were used to compare students across examinations.

Statistical Procedures

3.30 AE. The AE cohorts passed the test for equal variances. The ANOVA statistical test was used to compare both cohorts for on-the-job performance marks and for Third Class Advancement Examination scores.

3.31 EN and MM. The EN and MM cohorts failed the equal variance test for both performance marks and examination test scores. Therefore, the two-tailed t-test was used to compare the ISD-type graduates with all E-3s who had on-the-job performance marks submitted for that test period as well as with A-school graduates who took the Third Class Advancement Examination.

3.32 Tables. Tables 3.3 through 3.8 illustrate the results of the analysis. They were formatted as follows:

- Column 1 gives the date of examination and indicates whether the table contains on-the-job performance marks or standard scores for third class examination results.
- Column 2 shows the means, standard deviations, and sample sizes for the ISD-type graduates.
- Column 3 gives the means, standard deviations, and sample sizes for the comparison groups. The heading at the top of the column indicates the type of comparison group: TI, A-school graduates or all E-3s within the respective rate.

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TABLE 3.3
AE ON-THE-JOB PERFORMANCE MARKS

Category	ISD-Type	TI	ANOVA F-Ratio	$\alpha = 0.01$ Level	$\alpha = 0.05$ Level
Performance marks, August 1975	M = 3.52 S = 0.14 N = 15	M = 3.55 S = 0.16 N = 19	0.46	No F = 7.50	No F = 4.15
Performance marks, February 1976	M = 3.59 S = 0.15 N = 5	M = 3.59 S = 0.18 N = 57	0.0015	No F = 7.08	No F = 4.00
Performance marks, August 1976	M = 3.59 S = 0.19 N = 133	M = 3.54 S = 0.20 N = 99	3.59	No F = 6.70	No F = 3.86
Performance marks over-all cycles	M = 3.58 S = 0.18 N = 153	M = 3.56 S = 0.19 N = 175	1.47	No F = 6.70	No F = 3.86
BTB scores*	M = 169.97 S = 16.26 N = 153	M = 169.62 S = 14.57 N = 175	0.04	No F = 6.70	No F = 3.86

Note: M is mean, S is standard deviation, and N is number.

* BTB score = ARI + 2 ETST.

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TABLE 3.4
EN ON-THE-JOB PERFORMANCE MARKS

Category	ISD-Type	All EN E-3s	t Statistic	$\alpha = 0.01$ Level	$\alpha = 0.05$ Level
Performance marks, August 1975	M = 3.57 S = 0.19 N = 57	M = 3.53 S = 0.20 N = 480	1.42	No t = 2.65	No t = 2.00
Performance marks, February 1976	M = 3.58 S = 0.20 N = 151	M = 3.55 S = 0.18 N = 651	1.80	No t = 2.60	No t = 1.97
Performance marks, August 1976	M = 3.50 S = 0.22 N = 41	M = 3.55 S = 0.19 N = 519	1.51	No t = 2.67	No t = 2.01
Performance marks over all cycles	M = 3.56 S = 0.20 N = 249	M = 3.54 S = 0.19 N = 1,650	1.48	No t = 2.58	No t = 1.96

Note: M is mean, S is standard deviation, and N is number.

TABLE 3.5
MM ON-THE-JOB PERFORMANCE MARKS

Category	ISD-Type	All MM E-3s	t Statistic	$\alpha = 0.01$ Level	$\alpha = 0.05$ Level
Performance marks, August 1975	M = 3.52 S = 0.21 N = 62	M = 3.52 S = 0.20 N = 730	0.28	No t = 2.64	No t = 1.99
Performance marks, February 1976	M = 3.53 S = 0.34 N = 110	M = 3.54 S = 0.20 N = 820	0.23	No t = 2.60	No t = 1.97
Performance marks, August 1976	M = 3.53 S = 0.18 N = 29	M = 3.56 S = 0.20 N = 912	0.81	No t = 2.76	No t = 2.05
Performance marks over all cycles	M = 3.53 S = 0.29 N = 201	M = 3.54 S = 0.20 N = 2,462	0.50	No t = 2.60	No t = 1.97

Note: M is mean, S is standard deviation, and N is number.

TABLE 3.6
 AE PERFORMANCE ON THIRD CLASS ADVANCEMENT EXAMINATION

Category	ISD-Type	TI	ANOVA F-Ratio	$\alpha = 0.01$ Level	$\alpha = 0.05$ Level
Standard scores, August 1975	M = 55.47 S = 8.51 N = 15	M = 52.63 S = 9.25 N = 19	0.84	No F = 7.50	No F = 4.15
Standard scores, February 1976	M = 52.60 S = 10.95 N = 5	M = 50.25 S = 6.84 N = 57	2.35	No F = 7.08	No F = 4.00
Standard scores, August 1976	M = 52.08 S = 8.34 N = 133	M = 51.14 S = 9.20 N = 99	0.66	No F = 6.70	No F = 3.86
Number right overall	M = 78.47 S = 14.26 N = 153	M = 76.79 S = 14.43 N = 175	1.14	No F = 6.70	No F = 3.86

Note: M is mean, S is standard deviation, and N is number.

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TABLE 3.7
EN PERFORMANCE ON THIRD CLASS ADVANCEMENT EXAMINATION

Category	ISD-Type	A-School Graduates	t Statistic	$\alpha = 0.01$ Level	$\alpha = 0.05$ Level
Standard scores, August 1975	M = 52.26 S = 9.99 N = 57	M = 55.34 S = 8.96 N = 249	2.14	No t = 2.65	Yes t = 2.00
Standard scores, February 1976	M = 53.90 S = 7.97 N = 151	M = 53.44 S = 8.88 N = 342	0.57	No t = 2.60	No t = 1.97
Standard scores, August 1976	M = 55.38 S = 10.21 N = 42	M = 53.35 S = 9.08 N = 319	1.23	No t = 2.67	No t = 2.00

Note: M is mean, S is standard deviation, and N is number.

TABLE 3.8
MM PERFORMANCE ON THIRD CLASS ADVANCEMENT EXAMINATION

Category	ISD-Type	A-School Graduates	t Statistic	$\alpha = 0.01$ Level	$\alpha = 0.05$ Level
Standard scores, August 1975	M = 51.37 S = 8.25 N = 62	M = 54.70 S = 10.21 N = 418	2.87	Yes t = 2.64	Yes t = 1.99
Standard scores, February 1976	M = 53.80 S = 6.93 N = 110	M = 53.51 S = 9.11 N = 472	0.38	No t = 2.60	No t = 1.97
Standard scores, August 1976	M = 56.90 S = 7.16 N = 29	M = 53.67 S = 9.55 N = 512	2.31	No t = 2.75	Yes t = 2.04

Note: M is mean, S is standard deviation, and N is number.

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- Column 4 lists the ANOVA F-ratio or t-statistic.
- Columns 5 and 6 present the appropriate F- or t-values for the level of significance at $\alpha = 0.01$ and $\alpha = 0.05$ and whether the significance at the $\alpha = 0.01$ and $\alpha = 0.05$ levels is confirmed or negated.

For more details on the statistical methodology, see Appendix C.

Results of On-the-Job Performance Marks Analysis

3.33 AE. Table 3.3 illustrates the results of the AE ISD-type and TI graduates' on-the-job performance marks. The results were:

- a. TI graduates had higher on-the-job performance marks than the ISD-type graduates for the August 1975 test period, but the difference was not significant ^{8/}
- b. The ISD-type and TI graduates had the same on-the-job performance marks submitted for the February 1976 test period

^{8/} The 19 TI graduates had an average of 6 months of service from graduation until August 1975. The 15 ISD-type graduates had an average of 2 months and 9 days of service from graduation until August 1975; this may account for the lower performance marks for the ISD-type graduates.

- c. The ISD-type graduates had higher on-the-job performance marks submitted for the August 1976 test period
- d. When the ISD-type graduates were compared with all TI graduates over all three test periods, the ISD-type graduates had higher on-the-job performance marks
- e. The differences on the four comparisons were not significant
- f. The BTB scores of the ISD-type graduates were higher, but the difference was not significant.

3.34 EN. Table 3.4 illustrates the results of the EN ISD-type graduates and all EN E-3s who had on-the-job performance marks submitted. The results were:

- a. The ISD-type graduates had higher mean on-the-job performance marks submitted for the first two test periods .
- b. The TI graduates had higher mean on-the-job performance marks submitted for the last test period
- c. When the ISD-type graduates were compared with all the EN E-3s over all three test periods, the ISD-type graduates had higher on-the-job performance
- d. None of the four comparisons was significantly different.

3.35 MM. Table 3.5 illustrates the results of the MM ISD-type graduates and all MM E-3s who had on-the-job performance marks submitted. The results were:

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- a. The ISD-type graduates and all the MM E-3s had the same mean scores submitted for the August 1975 test period
- b. The ISD-type graduate had lower on-the-job performance marks submitted for the last two test periods
- c. When the on-the-job performance marks were compared over all three tests, the ISD-type graduates had lower mean scores than all the MM E-3s
- d. None of the four comparisons was significantly different.

Conclusions for On-the-Job Performance Marks

3.36 The conclusions for this portion of the study were based on a significance level of $\alpha = 0.01$. They were:

- There was no difference between the mean on-the-job performance marks of the ISD-type and TI graduates from the AE school
- There was no difference between the mean BTB scores of the ISD-type and TI graduates selected for the AE school
- There was no difference between the mean on-the-job performance marks of the EN ISD-type graduates and all EN E-3s recommended for promotion to Third Class
- There was no difference between the mean on-the-job performance marks of the MM ISD-type graduates and all MM E-3s recommended for promotion to Third Class.

Results of Third Class Advancement Examination Analysis

3.37 AE. Table 3.6 illustrates the results of the AE ISD-type and TI graduates' performances on the Third Class Advancement Examination:

- a. The ISD-type graduates had higher mean standard scores on each examination than the TI graduates
- b. The ISD-type graduates had higher mean raw scores for all examinations than the TI graduates
- c. The ISD-type graduates had higher mean scores on all four comparisons, but none of the differences was significant at either level.

3.38 EN. Table 3.7 illustrates the results of the performances of the ISD-type and A-school graduates from the EN courses on the Third Class Advancement Examination:

- a. The A-school graduates did better than the ISD-type graduates on the August 1975 test:
 1. The difference was not significant at the $\alpha = 0.01$ level
 2. The difference was significant at the $\alpha = 0.05$ level
- b. The ISD-type graduates had higher mean scores on the second and third examinations:
 1. The differences were not significant at either level.

3.39 MM. Table 3.8 illustrates the results of the comparison between ISD-type and all A-school graduates on the Third Class Advancement Examination:

- a. The A-school graduates had higher test scores on the August 1975 examination (the difference was significant at both levels)
- b. The ISD-type graduates had higher test scores on the February 1976 examination (the difference was not significant at either level)
- c. The ISD-type graduates had higher test scores on the August 1976 examination (the difference was not significant at the $\alpha = 0.01$ level; the difference was significant at the $\alpha = 0.05$ level).

Conclusions for Third Class Advancement Examination

3.40 The conclusions for this portion of the study were based on a significance level of $\alpha = 0.01$. They were:

- There was no difference between mean scores on the Third Class Advancement Examination of the ISD-type and TI graduates of the AE course
- There was no difference between the mean scores on the Third Class Advancement Examination of the ISD-type and all EN E-3 graduates of the EN A-school

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- There was no difference between the scores on the Third Class Advancement Examination of the ISD-type and all MM E-3s who graduated from the MM A-school.

IV. FINDINGS AND CONCLUSIONS

4.1 This section presents the findings and conclusions of the research effort. The research, primary data gathering, and analysis were directed towards graduate quality. Two types of comparison were made: (a) comparison of graduate quality from ISD-type courses with graduate quality from the same courses in a TI configuration and (b) curriculum review comparison of the curriculum, AOB, attrition, and costs of the courses selected for research.

FINDINGS

Curriculum Review

4.2 Curriculum. The following were the major findings from the ISD-type and TI curricula comparison:

- a. The AV A course ISD-type curriculum contained all the major units that were in the TI curriculum, but the course hours were shortened to 485.5 contact-hours from 511.7 contact-hours.
- b. The most noticeable difference in the AE A course ISD-type curriculum was the inclusion of a specific troubleshooting unit rather than the treatment of troubleshooting as a non-specific element of other units.

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- c. No theory units were specified in the ISD-type Basic Propulsion Engineering (PE) Course, and there was a considerable change in the equipment included in the two courses.

4.3 AOB. Major findings from the TI and ISD-type course AOB contrast are as follows:

- a. There were significant reductions in AOB in the EN and MM A courses.
- b. No change in AOB in the AE A course occurred. The course was not self-paced in either the ISD-type or TI configuration, and the course length remained at 11 wk.

4.4 Attrition. The comparison of TI and ISD-type courses' attrition provided the following data:

- a. Both academic and total attrition were worse in the AV A and basic PE ISD-type courses than in the TI configuration.
- b. AE A course ISD-type academic attrition was the same, and total attrition was better than in the TI configuration.
- c. The range of academic attrition for the three courses was 0.9% to 5.5%, and total attrition had a range of 1.5% to 11.2%.

4.5 Cost. The following were the major findings from the TI and ISD-type course per-capita-cost-to-train contrast:

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- a. The per capita cost to train for all four of the courses examined was higher for the ISD-type configuration than the TI configuration, but three of the four course costs were well within the range attributable to inflationary influences.
- b. The fourth ISD-type course (EN A) cost was influenced by a large construction investment expense.
- c. Given present cost accounting procedures, a major study that is cost oriented would be necessary to analyze the cost impact of converting a course to ISD from TI.

Graduate Quality

4.6 The major findings from the quantitative analysis of Section III are described in the following paragraphs. They are grouped first by each ISD-type course studied, and then by career points as defined in Paragraph 3.1. Table 4.1 summarizes the findings.

Avionics Technician (AV) Course

4.7 The AV ISD-type graduates were evaluated at the Advanced First Term Avionics (AFTA) Course (a follow-on B-school). Each AFTA student was graded in four test areas, and a final course grade was assigned. The findings were as follows:

TABLE 4.1
RESULTS OF ISD-TYPE COMPARISONS WITH COMPARISON COHORTS

Graduates	Comparison	Follow-on Courses	On-the-Job Performance Marks	Third Class Advancement Examination
Avionics Technician (AV)	Final course grade	B	None	None
	Comprehensive exam	B	None	None
	Performance test 1/	B*	None	None
	Written test	B	None	None
	Practical work	B*	None	None
	Basic Test Battery 2/	B	None	None
	BNG--ISD-type vs. TI 3/	W	--	--
Aviation Electrician's Mate (AE)	BNG--ISD-type vs. others	W	--	--
	AHL--ISD-type vs. TI	B	--	--
	AHL--ISD-type vs. others	B	--	--
	FEG--ISD-type vs. TI	B	--	--
	FEG--ISD-type vs. others	B	--	--
	FEH--ISD-type vs. TI	B	--	--
	FEH--ISD-type vs. others	B	--	--
	August 1975	--	W	B
	February 1976	--	S	B
	August 1976	--	B	B
	All three tests periods	--	B	B
	Basic Test Battery 2/	--	B	B

TABLE 4.1 (Cont)

Graduates	Comparison	Follow-on Courses	On-the-Job Performance Marks	Third Class Advancement Examination
Engineman (EN)	August 1975	None	B	W
	February 1976	None	B	B
	August 1976	None	W	B
	All three test periods	None	B	None
Machinists Mates (MM)	August 1975	None	S	W*
	February 1976	None	W	B
	August 1976	None	W	B
	All three test periods	None	W	None

Legend:

B--ISD-type had better performance than the comparison cohorts

S--ISD-type and comparison cohorts had same performance

W--ISD-type had worse performance than the comparison cohort

*--Difference in performance was significant at the $\alpha = 0.01$ level.1/ AFTA course.2/ Prerequisite BTB scores.3/ NAMTRAGRU courses (see footnotes of Table 3.2 on p. 40).

- a. The ISD-type graduates' grades in the two test areas of practical work and performance tests were significantly $\frac{1}{2}$ higher than the TI graduates' grades.
- b. The ISD-type graduates' grades in the areas of written tests and comprehensive examinations were higher than the TI graduates' grades.
- c. The final course grade is a weighted composite of the four test grades just discussed. The ISD-type had higher final grades, but they are not significantly higher.
- d. The ISD-type graduates had higher prerequisite Basic Test Battery (BTB) scores used for selection to the AV course, but they were not significantly higher.

Aviation Electrician's Mate (AE) Course

4.8 The AE ISD-type graduates were evaluated at three career points: Naval Air Maintenance Training Group (NAMTRAGRU) courses at Oceana, on-the-job performance marks submitted for promotion to Third Class and the scores on the Third Class Advancement Examination. ISD-type graduates were compared to TI graduates at all three career points. Additionally, ISD-type graduates were compared to all students taking the same course at the NAMTRAGRU. The findings were as follows:

$\frac{1}{2}$ The word significant used in this context indicates that the difference in the scores was statistically different at the $\alpha = 0.01$ level of significance.

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- a. The ISD-type graduates had higher final grades than the TI graduates and all students taking the three courses at the NAMTRAGRU. The differences were not significant.
- b. The ISD-type graduates' on-the-job performance marks submitted for the first promotion period (August 1975) were lower than the TI graduates'. For the second period (February 1976) they had the same marks, and for the third period (August 1976) the ISD-type graduates had higher marks. When all the ISD-type graduates' on-the-job performance marks were compared to all the TI graduates' marks, the former had higher scores. The differences were not significant.
- c. The ISD-type graduates had higher prerequisite BTB scores, but they were not significantly higher.
- d. The ISD-type graduates had higher Third Class Advancement Examination scores than the TI graduates on all three examinations. The scores were not significantly higher.

PE School

4.9 The Engineman (EN) and Machinists Mates (MM) ISD-type graduates were evaluated at two career points--on-the-job performance marks submitted for Third Class promotion and their scores on the Third Class Advancement Examination. A TI cohort could not be constructed from records available at the PE school. Therefore, performance marks were compared with all candidates

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taking the same Third Class Advancement Examination. The ISD-type graduates' scores on the examination were compared with the scores of all A-school graduates taking the same examination with the same rates and ratings. The findings were as follows:

- a. The EN ISD-type graduate had higher on-the-job performance marks submitted for the first two promotion periods (August 1975 and February 1976) and lower marks for the last period (August 1976). When all the ISD-type graduates were compared with all EN candidates for Third Class promotion, the ISD-type graduates had higher on-the-job performance marks. The differences were not significant.
- b. The EN ISD-type graduates had lower scores than the A-school graduates on the first Third Class Advancement Examination and higher scores on the last two examinations. The differences were not significant.
- c. The MM ISD-type graduates and all MM candidates for Third Class promotion had equal on-the-job performance marks submitted for the first period (August 1975), and the ISD-type graduates had lower on-the-job performance marks submitted for the last two periods (February and August 1976). When the comparison was made over the three test periods, the ISD-type graduates had lower performance marks. The differences were not significant.

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- d. The MM ISD-type graduates had significantly lower scores on the first Third Class Advancement Examination than the A-school graduates. The ISD-type graduates had higher scores on the last two Third Class Advancement Examinations.
- e. Comparison between graduates' test scores from the three different test periods on the Third Class Advancement Examination could not be made. The raw scores indicated the tests were significantly different (for both the ENs and MMs).

Career Points

4.10 The major findings at each career point are as follows:

- a. The ISD-type graduates performed better in the AFTA course and NAMTRAGRU courses. The performances were not significantly better.
- b. The on-the-job performance marks were mixed for each rating, with the AE and EN ISD-type graduates having better on-the-job performance marks and the MM having lower performance marks than their non-ISD-type cohorts. The ISD-type graduates' on-the-job performance marks were not significantly different than the performance marks of the other candidates for promotion to Third Class.

- c. The ISD-type graduates' scores on the Third Class Advancement Examination indicated mixed results. The only comparison that was significant was the MMs' scores on the first test, where the ISD-type graduates had significantly lower scores than the A-school graduates. The ISD-type graduates did, however, have higher scores on seven of nine tests, but eight of the nine comparisons indicated there was no significant difference between ISD-type graduates' scores and the A-school graduates' scores.

CONCLUSIONS

4.11 The conclusions in the following paragraphs must be considered inferential in their application to ISD courses since research had to be restricted to ISD-type courses.

Curriculum Review

4.12 The following conclusions were made concerning ISD-type and TI course curricula:

- a. ISD-type courses contained less specifically identified theory than did TI courses.
- b. Changing to an ISD-type configuration did imply a high probability of reducing AOB.
- c. Academic and total attrition may get better or worse after an ISD-type conversion. Because self-pacing, student quality, and quality of course after conversion are also significant factors in determining attrition, the changes in attrition could not be directly linked solely to the type of course.

No costing conclusions could be made regarding the ISD-type course compared to the TI configuration.

Graduate Quality

4.13 The graduate quality from ISD-type courses is equivalent to TI course graduates in terms of performance in follow-on training, on-the-job performance, and in Third Class Advancement Examination results.

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APPENDIX B
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APPENDIX C
STATISTICAL METHODOLOGY

C.1 This study required that decisions about populations be based on sample information. Such determinations are called statistical decisions. For example, one may wish to decide on the basis of sample data whether a certain educational process, viz., traditional instruction, is better than another, viz., instructional systems development (ISD) type. To make statistical decisions, the following steps were followed:

- Define a statistical hypothesis
- Select a level of significance for testing
- Determine the appropriate statistical test
- Test the hypothesis
- State the results.

STATISTICAL HYPOTHESES

C.2 In attempting to reach decisions, assumptions or inferences about the populations must be made. Such assumptions, which may or may not be true, are called statistical hypotheses and in general are statements about the probability distributions of the populations.

C.3 In many instances statistical hypotheses are formulated for the sole purpose of rejecting or nullifying them. For

example, to decide whether one educational process is better than another, the hypothesis is formulated that there is no difference between the graduates from the two processes (i.e., any observed differences are merely due to fluctuation in sampling from the same population). Such hypotheses are called null hypotheses.

C.4 Any hypothesis that differs from a given hypothesis is called an alternative hypothesis. For example, if one hypothesis asserts "there is no difference between TI and ISD-type graduates," the alternative hypothesis is, "there is a difference between TI and ISD-type graduates."

Tests of Hypotheses and Significance

C.5 Given that a particular hypothesis is true, if results observed in a random sample differ markedly from those expected on the basis of pure chance using sample theory, it would indicate that the observed differences are significant and that the hypothesis should be rejected (or at least not accepted on the basis of the evidence obtained).

C.6 Statistical procedures that enable the analysis to accept or reject hypotheses or to determine whether observed samples differ significantly from expected results are called tests of hypotheses.

Type I and Type II Errors

C.7 If the hypothesis is rejected when it should have been accepted, then a Type I error has been made. If, on the other hand, the hypothesis is accepted when it should have been rejected, a Type II error has been made. In either case a wrong decision or error in judgment has occurred.

C.8 For any test of hypothesis to be valid, it must be designed to minimize the error of decision. This is not a simple matter since, for a given sample size, an attempt to decrease one type of error is generally accompanied by an increase in the other type of error. The only way to reduce both types of error is to increase the sample size.

LEVEL OF SIGNIFICANCE

C.9 In testing a given hypothesis, the maximum probability with which one is willing to risk a Type I error is called the level of significance of the test. This probability, denoted by α , is generally specified before any samples are drawn, so the results obtained will not influence the choice.

C.10 In practice a level of significance of 0.05 or 0.01 is used for testing, although other values are sometimes used. If, for example, a 0.05 (or 5%) level of significance is chosen in designing a test of hypothesis, then there are about 5 chances in 100 that the hypothesis would be rejected when it should be accepted, i.e., one is 95% confident that the right decision is made. In such cases it is said that the hypothesis has been rejected at a 0.05 level of significance, which means that it could be wrong with a probability of 0.05.

C.11 The sample sizes used in this study were very large whenever sufficient data were available. All tests of hypotheses were null hypotheses, e.g., "there is no difference between the two comparison groups." A level of significance of $\alpha = 0.01$ was selected to decrease the Type I error, and large sample sizes made the probability of making a Type II error almost zero. All tables illustrating statistical results give information on both $\alpha = 0.01$ and $\alpha = 0.05$ levels of significance, so

that the reader can decide how critical the level of $\alpha = 0.01$ was to the results of the analysis.

DETERMINATION OF APPROPRIATE STATISTICAL TEST

C.12 Two statistical tests were selected to test the differences between two population means. The first test was a one-way analysis of variance (ANOVA) with two treatment groups (which assumes that both populations have equal variances). The second test was a two-tailed t-test (which assumes that the variances are unequal). To determine the appropriate test, the F-ratio was used to test the hypothesis that the two populations had equal variances against the alternative hypothesis, i.e., the two populations have unequal variances). To facilitate discussion of the three statistical tests used, the basic definitions are furnished below:

- N_i = sample size of sample i
- \bar{X}_i = mean of sample i
- S_i = standard deviation of sample i
- S_i^2 = variance of sample i.

F-Ratio Test

C.13 The F-ratio test is appropriate for the following hypotheses:

- Hypothesis: Both populations have equal variances
- Alternative hypothesis: The population variances are unequal.

The test requires

$$F = \frac{S_1^2}{S_2^2} = \frac{\text{larger sample variance}}{\text{smaller sample variance}}$$

to be calculated. The hypothesis is only rejected if

$$F \geq F_{(1 - \frac{\alpha}{2})} (N_1 - 1, N_2 - 1)$$

where $N_1 - 1$ and $N_2 - 1$ represent, respectively, the degrees of freedom associated with the numerator and denominator. The F-value is found by using the degrees of freedom and $(1 - \frac{\alpha}{2})$ value to enter a cumulative F-distribution table.

C.14 Example. Using the data from the Advanced First Term Avionics (AFTA) Course (performance tests), the results are:

<u>TI Student</u>	<u>ISD-Type Student</u>
$N_1 = 204$	$N_2 = 335$
$\bar{X}_1 = 80.55$	$\bar{X}_2 = 82.69$
$S_1 = 6.38$	$S_2 = 5.18$
$S_1^2 = 40.70$	$S_2^2 = 26.83$

Next there is

$$F = \frac{40.70}{26.83} = 1.52$$

and

$$F_{(0.995)} (203, 334) = 1.28.$$

Since $F = 1.52$ is greater than $F_{(0.995)}(203, 334) = 1.28$, the hypothesis is rejected and the two-tailed t-test is used.

ANOVA

C.15 The one-way ANOVA tests the differences between the population means of k treatment groups. For this analysis, k always equaled 2 (ISD type and TI). Then if group i has N_i observations and there are only two treatment groups, the following exists:

$$\begin{aligned} \text{Sum } i &= \text{Sum of observations in group } i \\ &= \sum_{j=1}^{N_i} x_{ij} \end{aligned}$$

$$\begin{aligned} \text{Sum Sq} &= \text{Sum of the squares of each observation} \\ &= \sum_{i=1}^k \sum_{j=1}^{N_i} x_{ij}^2 \end{aligned}$$

$$\text{Total SS} = \text{Sum Sq} - \frac{(\text{Sum}_1 + \text{Sum}_2)^2}{N_1 + N_2}$$

$$\text{Treat SS} = \frac{(\text{Sum}_1)^2}{N_1} + \frac{(\text{Sum}_2)^2}{N_2} - \frac{(\text{Sum}_1 + \text{Sum}_2)^2}{N_1 + N_2}$$

$$\text{Error SS} = \text{Total SS} - \text{Treat SS}$$

$$df_1 = \text{Number of treatments} - 1$$

$$df_2 = N_1 + N_2 - 2$$

$$\text{Treat MS} = \frac{\text{Treat SS}}{df_1}$$

$$\text{Error MS} = \frac{\text{Error SS}}{df_2}$$

$$F = \frac{\text{Treat MS}}{\text{Error MS}}$$

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The ANOVA with two treatment groups tests the following hypotheses:

- Hypothesis: Both populations have equal means
- Alternative hypothesis: The population means are unequal.

The hypothesis is rejected only if

$$F \geq F_{(1 - \alpha)} (df_1, df_2)$$

where df_1 and df_2 are the degrees of freedom. The F-value is found by using the degrees of freedom and the $(1 - \alpha)$ value to enter the cumulative F-distribution table.

C.16 Example. Using the data from the Aviation Electrician's Mate (AE) performance on the Third Class Advancement Examination for August 1975, then:

$$\begin{aligned} N_1 &= \text{number of ISD-type graduates} \\ &= 15 \end{aligned}$$

$$\begin{aligned} N_2 &= \text{number of TI graduates} \\ &= 19 \end{aligned}$$

$$\begin{aligned} \text{Sum}_1 &= \text{sum of the standard scores for ISD-type graduates} \\ &= 832.0 \end{aligned}$$

$$\begin{aligned} \text{Sum}_2 &= \text{sum of the standard scores for TI graduates} \\ &= 1,000.0 \end{aligned}$$

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Sum Sq = sum of the square of each standard
score

$$= 101,334.0$$

$$\text{Total SS} = 101,334 - \frac{(1,832)^2}{34} = 2,621.53$$

$$\text{Treat SS} = \frac{(832)^2}{15} + \frac{(1,000)^2}{19} - \frac{(1,832)^2}{34} = 67.38$$

$$\text{Error SS} = 2,621.53 - 67.38 = 2,554.15$$

$$df_1 = 1$$

$$df_2 = 2$$

$$\text{Treat MS} = \frac{67.38}{1} = 67.38$$

$$\text{Error MS} = \frac{2,554.15}{32} = 79.82$$

$$F = \frac{67.38}{79.82} = 0.84$$

and $F_{(0.99)} (1,32) = 7.50.$

Therefore the hypothesis is accepted, and it can be concluded that there is no difference in the performances of the ISD-type and TI graduates on the August 1975 examination at the $\alpha = 0.01$ level.

Two-Tailed t-Test

C.17 The two-tailed t-test is used to test the hypothesis when equal variances cannot be assumed.

- Hypothesis: Both populations have equal means
- Alternative hypothesis: The population means are unequal.

Compute the t-statistic using: -

$$t = \frac{(\bar{X}_1 - \bar{X}_2)}{\left(\frac{S_1^2}{N_1} + \frac{S_2^2}{N_2}\right)^{1/2}}$$

and the t' value

$$t' = \frac{\left(\frac{S_1^2}{N_1} t_1 + \frac{S_2^2}{N_2} t_2\right)}{\left(\frac{S_1^2}{N_1} + \frac{S_2^2}{N_2}\right)^{1/2}}$$

where $t_1 = t_{(1 - \frac{\alpha}{2}) (N_1 - 1)}$

and $t_2 = t_{(1 - \frac{\alpha}{2}) (N_2 - 1)}$

and reject the hypothesis if the absolute value of

$$|t| \geq t'.$$

The values of t_1 and t_2 are found by entering the cumulative t-distribution tables with $(1 - \frac{\alpha}{2})$ and $(N_1 - 1)$ or $(N_2 - 1)$ degrees of freedom.

C.18 Example. Again using the data from the AFTA course for the performance tests, the following is computed,

$$t = \frac{(80.55 - 82.69)}{\left(\frac{40.70}{204} + \frac{26.83}{335}\right)^{1/2}}$$

or

$$t = -4.047$$

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GRADUATE PERFORMANCE COMPARISON: INSTRUCTIONAL SYSTEMS DEVELOPM--ETC(U)

JUL 77 E E BROWN, G A ADAMSON, R P MACK

N00014-73-C-0081

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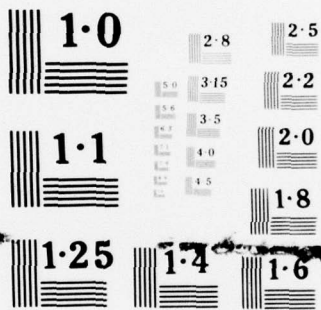
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NATIONAL BUREAU OF STANDARDS
MICROCOPY RESOLUTION TEST CHART

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or

$$|t| = 4.047$$

and compute t'

where $t_1 = t_{(0.995)}(203) = 2.592$

and $t_2 = t_{(0.995)}(334) = 2.588$

then
$$t' = \frac{\left(\frac{40.70 \times 2.592}{204} + \frac{26.83 \times 2.588}{335} \right)}{\left(\frac{40.70}{204} + \frac{26.83}{335} \right)^{1/2}}$$

or

$$t' = 2.5909.$$

Since 4.047 is greater than 2.5909, the hypothesis is rejected at the $\alpha = 0.01$ level and the alternative hypothesis is accepted. Then the statement can be made that the ISD-type student had significantly higher scores than the TI student.

SUMMARY

C.19 To make the statistical decisions required for this study, the following procedure was used:

- The statistical hypothesis was defined
- A significance level of $\alpha = 0.01$ was selected
- The appropriate statistical test was determined using the F-ratio test
 - Equal variances use ANOVA
 - Unequal variances use two-tailed t-test

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- The hypothesis was tested
- The results were stated.

C.20 There are many other statistics that could have been used for this study, but the results would have been similar. Sample sizes were sufficiently large to reduce both Type I and Type II errors to an acceptable level.